A study on the type of lesions achieved by three electrosurgical methods and their way of healing

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Abstract
The technical progress in the medical sector in the past decades has continuously driven the development of electrosurgical techniques. The controversies surrounding the priority of a certain technique relative to another – electrocautery, laser and radiofrequency – have determined us to carry out a histopathological design with the aim of comparing the healing sort of the shallow wounds generated by the three types of electrosurgical devices. The experimental study has investigated the healing process inflicted by the electrosurgical devices mentioned beforehand on 12 Wistar albino rats. The wounds were inflicted under intravenous general anesthesia with Xylazine and Ketamine and were performed lateral to the spine region, using laser, radiofrequency and electric cautery. The histological samples harvested at one, three, five, and seven days were sent to pathological examination. We followed by comparison the evolution of the first two phases of the wound healing produced by the three electrosurgical methods analyzed. We described the histopathological changes occurred in the epidermis, dermis and hypodermis and also the subcutaneous soft tissues in all of the three types of lesions. Electrocautery remains the most frequently used electrosurgical device, even if it has unquestionable disadvantages as compared to other modern instruments. Laser-assisted surgery and radiofrequency are refine energy-based instrumentation, being utilized at a multidisciplinary surgical level.

Keywords: electrocautery, radiofrequency, laser-assisted surgery, wound healing.

Introduction
The technical progress in the medical sector in the past decades has continuously driven the development of electrosurgical techniques, with a final purpose of improving the post-operative results, shortening the hospital stay, and leading to a more physiological healing of the surgical wounds [1, 2].

The first steps in the development of electrosurgical devices were represented by the appearance of conventional mono- and later bi-polar cautery. This energy-based surgical instrumentation helped us to perform incisions with less bleeding but were less precise and associated significant thermal damage not only to incised tissues but also to the adjacent structures [3, 4]. The next techniques to appear, i.e., radiofrequency (RF), laser and coablation, have further improved the surgical technique by reducing the thermal damage during dissection while maintaining bleeding control [5, 6].

The controversies surrounding the priority of a certain technique relative to another have determined us to set up an experimental study with the aim of inves-

ISSN (print) 1220–0522
ISSN (on-line) 2066–8279
Research question: Are there differences in the wounds and subsequently in the healing process of incisions produced by three competing electrosurgical technologies?

Methods
The study compares incisions made by the CURIS, Erbe HF and CO$_2$ laser
The incisions were made in a rat model
Histopathological evaluation was performed on incisions by the 3 machines at multiple time points:
  • On day 1 to investigate thermal damage in the surrounding tissue
  • And days 3, 5, 7 in order to evaluate the speed of post-op wound healing
The power settings were: CURIS = 10 Watt, Erbe ICC 50 = 35 Watt, CO$_2$ laser = 2.5 Watt.

Results:
Day 1
  • The CURIS RF incisions had the least thermal damage, least necrosis, less inflammation
  • In the RF-induced incisions the basal layers were still intact (=> faster wound healing)
  • For HF and laser there was significantly more necrosis and deeper thermal damage

Day 3
  • In the RF-induced incisions the wound healing has already begun (proliferative phase)
  • For laser and especially the Erbe HF incisions, the inflammatory reaction is more present due to higher level of tissue necrosis.

Day 5
  • The laser based wounds start to heal with reepithelialization
  • The electrosurgical wounds still demonstrate extensive lesions, epithelialization is delayed

Day 7
  • Reepithelialization is complete in the RF-induced wounds
  • The lesions by laser were reepithelialized
  • The HF-generated wounds were not healed and abundant inflammation persisted

Conclusions:
The CURIS RF Generator produces less invasive lesions and the wound healing starts earlier

Authors: G. Mühlfay, K.U. Horvath, et al.
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The skin has three main layers - the epidermis, the dermis and the hypodermis or subcutaneous layer.

The epidermis is the outer layer. This has a basal layer which is always forming new cells through cell division so the epidermis is made up from layers of cells. The new cells gradually move towards the surface, which takes 1-2 months. As they move up they gradually die, become flattened and develop keratin. The outermost layer of the epidermis is made of flat dead cells which are continually worn away by friction. The keratin and oil from the sebaceous glands help to make the skin waterproof.

The dermis is the middle layer. It contains
- Connective tissue - packs and binds the other structures in the skin.
- Elastic fibres - make the skin stretchy and resilient.
- Capillaries - tiny blood vessels which are supplied by arterioles.
- Hair erector muscles - to move the position of the hairs.
- Sensory cells - these respond to sense touch, pressure, heat, cold and pain.
- Nerve fibres - to activate muscles and glands and relay messages from the sensory cells to the brain.
- Pigment cells which produce melanin - a very dark pigment.
- Sweat glands which open onto the surface as pores.
- Hair follicles - pits in the epidermis which grow hairs.
- Sebaceous glands - produce oil to keep hair follicle free from dust and bacteria, and to help to waterproof the skin.

The hypodermis layer, also known as subcutaneous layer, is the final layer of the skin. This is a layer of fat found in the lower part of the dermis and underneath it. The thickness of this layer varies depending on the place in the body and from person to person. A store of fat is useful to the body as insulation and it can be used for energy when the intake of nutrients is insufficient.
Info: The Process of Healing of Skin Wounds

This process is divided into predictable phases: inflammation, tissue growth (proliferation) and tissue remodeling (maturation). Blood clotting may be considered to be part of the inflammation stage.

1. **Inflammation**: During this phase, damaged and dead cells are cleared out, along with bacteria and other pathogens or debris. This happens through the process of phagocytosis, where white blood cells "eat" debris by engulfing it. Platelet-derived growth factors are released into the wound that cause the migration and division of cells during the proliferative phase.

2. During **proliferation**, the wound is ‘rebuilt’ with new granulation tissue which is comprised of collagen and extracellular matrix and into which a new network of blood vessels develop, a process known as ‘angiogenesis’. Healthy granulation tissue is dependent upon the fibroblast receiving sufficient levels of oxygen and nutrients supplied by the blood vessels. Healthy granulation tissue is granular and uneven in texture; it does not bleed easily and is pink / red in colour. Epithelial cells finally resurface the wound, a process known as ‘epithelialisation’.

3. **Maturation** (remodeling): During maturation and remodeling, collagen is realigned along tension lines, and cells that are no longer needed are removed by programmed cell death.

The study by G. Mühlfay et al. investigates the first two phases of wound healing: the inflammation and the proliferation phases. The authors findings are clear that the radiofrequency induced incisions produce less thermal damage and heat dispersion. Furthermore, **the proliferation phase starts earliest in the wounds created by the CURIS: the proliferation of new cells starts at day 3 already, where as the wound healing is delayed for laser (day 5) and electrosurgery (has not even started at day 7).**

**Graphical representation of the three phases of wound healing**

Source: [http://www.clinimed.co.uk/Wound-Care/Education/Wound-Essentials/Phases-of-Wound-Healing.aspx](http://www.clinimed.co.uk/Wound-Care/Education/Wound-Essentials/Phases-of-Wound-Healing.aspx)